



Research Article

PREDICTING BODY WEIGHT FROM BODY MEASUREMENTS IN ADULT FEMALE SAHIWAL CATTLE

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Abstract- The study was undertaken to develop linear regression equations for prediction of body weights of Sahiwal cattle. The average height at wither (HT), body length (BL), and heart girth (HG) measurement were 124.25 ± 0.38 , 127.82 ± 0.53 and 169.45 ± 0.67 cm, respectively. Linear regressions indicated that combination of HT, BL and HG measurements can be useful in predicting body weight. HG was the most accurate predictor as a single explanatory variable ($R^2 = 0.626$) compared to HT ($R^2 = 0.539$) and BL ($R^2 = 0.526$). Effect of the three body measurements (HT, BL and HG) on BW was significant ($P < 0.05$). The live body weight can be estimated using the multiple regression equation of $Y = (-508.530*) + 2.100*(HT) + 1.567*(BL) + 2.187*(HG)$. The present study showed that heart girth measurement can be used to predict the live body weight of Sahiwal adult female cattle. Linear regressions method for prediction of live body weight is quick, cheap and practical under field conditions.

Keywords- Body weight, Sahiwal, Heart girth, Body length, Height at wither

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Introduction

Cattle are the most popular species among all livestock in India. Livestock continue to be the financial support of the vast majority of the rural households along with agriculture. Livestock keeping has been the major source of supplementary income for rural households next to agriculture. Animal husbandry has always been an integral part of the rural livelihood systems in India. Around 80% of marginal or small as well as landless farmers in India possess livestock of some species or the other. However, cattle are in the preference list. Crop production in India is almost dependent on work animals such as bullocks for farm power, cows for milk production and the primary objective of the farming community in the breeding of cattle, consequently, continues to be the production of work animals. The superior value of India's native cow breeds has attracted worldwide attention of people from all continents that have carried these breeds of their native lands and successfully rebred them there. Brazilians have raised thousands of Gir, Kankrej, Red Sindhi and Ongole cows of Indian origin, New Zealanders have redeveloped the Indian "Vachur" breed and Kenyans have developed Sahiwal breed. This outstanding achievement is the result of perception of future and of the persistence in the work in selection of breeders and environment. These achievements indicate that indigenous breeds can perform extremely well if they are selected for milk production and given right environment. Indigenous cattle (*Bos indicus*) compared to *Bos taurus* have lower basal metabolic rate, better capacity for heat dissipation through cutaneous evaporation due to extensive area covered by the dewlap, loose body skin, more sweat glands and these qualities play vital role in heat tolerance and adaptation to tropical heat. Locally cattle breeds will continue to be valuable in our country because our country cannot bear the inputs that are required to maintain breeds that have been developed in low stress, costly production systems. The body weight of dairy cows is important for several management purposes including assessment of feed efficiency, the value of culled cows, and the efficiency of rearing replacement heifer. Scientific feeding of farm animals is based on their body weight, and hence

the necessity of weight them periodically [7]. Periodical weighing of stock gives an idea about their condition and well-being. For practical reasons, body weight is difficult to obtain regularly, as weighing scales are cumbersome, expensive and difficult to transport specially in field condition. Small and marginal farmers cannot afford weighing scales because most farmers have not knowledge about how to use the weighing scales properly and it is also very expensive. Body measurements are simple and easily measured variables for estimating the live weight (LW). Linear body measurements such as body length (BL), heart girth (HG), abdominal girth (AG), height at wither (HT), height at hook (HH), etc. have close association with live body weight [12]. Such predicted body weight (BW) based on body measurements is having less variability because growth rate of cow is slower. However, breed performance and characterization of animals have been evaluated by using linear body measurements i.e. heart girth (HG) or combination with body length (BL) and withers height (HT) to develop predictive equations [16]. HG of many breeds of cattle has high coefficient of correlation (r) with live body weight [6]. Chest girth is best prediction parameter, which can be used to predict body weight more accurately [2]. Therefore, present experiment was conducted to develop prediction equations for live body weight estimation in adult Sahiwal cattle.

Materials and Methods

The material of the study that provided and the methodology adopted in the present research work is given here with as per the protocol given below [15].

Location of study

Chhattisgarh is one of the states under Indian subcontinent, falls under sub-tropical climate. Durg is situated at an elevation of 317 meters above mean sea level at Latitude and Longitudes between $20^{\circ}23'$ and $22^{\circ}02'$ N and $80^{\circ}46'$ and $81^{\circ}58'$ E. The place generally has a dry tropical weather which is moderate but on

a warmer side in summer season. The durg comes under monsoon climatic zone, with annual average highest temperatures of 45°C and average lowest temperature of 10°C. The wind velocity throughout year is 9-20mph. Durg district's annual average rainfall is 1052 MM. During the year, most rainfall occurs during the monsoon months June to September.

Selection of the animals

The present investigation was conducted in the herd of pure bred Sahiwal cows maintained at Bull Mother Experimental Farm (BMEF) of the College of Veterinary Science and Animal Husbandry, Anjora, Durg and Government Cattle Breeding Farm (CBF), Anjora, Durg of the Directorate of Veterinary Services, Raipur, Government of Chhattisgarh India. In present study a total of 193 female Sahiwal cattle over three years of age were used in the experiment. Pregnant animals and sick animals, animals with defects, etc. were not used for in present study, if at all present in the herd at the time of weighing.

Feeding and housing management

All the selected Sahiwal cows of the present investigation were kept under similar system of housing i.e. double row conventional barn housing with concrete flooring in BMEF and CBF at Anjora, Durg. The animals were on diet of green fodder, dry fodder and concentrates. The concentrate mixture was fed during morning and evening at the time of milking as per the practice followed in the farms. The concentrate mixture contained 20% crude protein, 0.93% ether extract, 18% crude fiber and 14% total ash. Ad lib drinking water was made available to all animals three times daily. In BMEF and CBF farm each cow provide Green fodders, Paddy straw and Concentrate at the rate of 1 Kg for maintenance and 0.5 Kg/ Kg milk produced for production

Distribution of data as per group

The adult female Sahiwal were grouped into eight age groups (3-4 years, 4-5 years, 5-6 years, 6-7 years, and 7-8, above 8 years old and 3 to above 8 years old). Age of the animals was determined and grouped conveniently. True types of animals were selected. A total of 193 adult female Sahiwal cattle were used in the experiment to the adult female animals over three year of age sex were considered under in present study. Pregnant animals and sick animals, animals with defects, etc. were not used for in present study, if at all present in the herd at the time of weighing. Weight and body measurements were carried out. Age of animals was recorded from History and Pedigree Register.

Methodological details of weighing of animal

Live body weight (BW) of each animal was taken individually and measured in kilograms prior to feeding during early in the morning between 6.00 am to 7.00 am before providing the animals with any feeding stuff or water. Weighing of individual animals was carried out using Digital Weighing Balance. Adult female Sahiwal cattle were secured well for weighing. The weights of animals were measured in kilogram (kg) unit up to two decimals.

Body measurements

Body measurement of animal is the distance between two different body contours. For different body measurements different anatomical points (bone joints) on the body of animals was considered. The body measurement of individual animals was carried out as per following procedure by flexible tape measure while the animals were motionless. Advance stage of pregnant animal was not taken for study purpose. Animal was allowed to stand on four legs squarely, relaxed / without stress and constant measurements were recorded.

Height at withers

The height of cattle was measured as vertical distance from the point of withers to the base of hoof. The distance was measured in centimeter.

Body length

The body length of cattle was measured as distance between point of shoulder to the point of the Tuberischii or Pin bone in cattle. The distance is measured in cm.

The body length from shoulder to pin bone was designated as Body Length.

Heart girth

In cattle, heart girth is the circumference of thoracic cavity immediately behind the forelimbs and parallel to the body axis. The distance was measured in centimeter. The heart girth was measured by flexible measuring tape as described by [5].

Statistical procedure

All the data collected were analyzed statistically through SPSS computer software version 17.0. The relationship of body weights and body measurements were estimated by simple correlation and regression[14]. The best estimation equations for body weight from other traits (height at wither, body length and heart girth) as independent variables were determined. Linear regression effects of independent variables on live weight were included in following model:-

$$Y_i = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \epsilon_i$$

Where, Y_i is the live weight observation of i^{th} animals; b_0 is the intercept; b_1 , b_2 and b_3 are the regression coefficient; X_1 is height at wither, X_2 is body length and X_3 is heart girth and ϵ_i is residual error term.

Results

The mean values of different morphometric traits (HT, BL and HG) are presented in [Table-1] and graph showed in [Fig-1]. The height at withers has been ranged from 119.667 ± 1.34 cm to 126.968 ± 0.63 cm from the age group of 3 years to above 8 years. Since these traits show slow increasing trends. The body length has been increased during present study up to the age of 5 years, however it become constant beyond this age. Therefore, it was seen that major body measurements like body length, height at withers and heart girth have profound role in early stages of animal's life cycle i.e. first two age groups (3-4 and 4-5) with higher growth compared to the rest of period. Age strongly influenced heart girth in mature adult Sahiwal cattle. There was a change in heart girth with advancement of age [Fig-1].

Table-1 Mean values (± SE) of different morphometric traits

Age groups (years)	BW (kg)	HT (cm)	Range (cm)	BL(cm)	Range (cm)	HG (cm)	Range (cm)
3-4	268.72 ±8.56	119.67 ±1.33	112.0-128.0	118.83 ±1.63	111.0-126.0	158.06 ±2.40	143.0-172.0
4-5	293.00 ±5.32	120.29 ±0.90	112.0-128.0	123.29 ±0.96	105.0-128.0	164.07 ±1.41	151.0-174.0
5-6	303.61 ±7.55	123.39 ±1.02	115.0-131.0	128.11 ±1.41	115.0-136.0	167.25 ±1.65	158.0-180.0
6-7	322.18 ±4.94	124.42 ±0.60	117.0-131.0	128.68 ±0.74	115.0-145.0	170.55 ±1.26	164.0-180.0
7-8	346.11 ±14.88	126.63 ±1.29	115.0-135.0	128.05 ±0.96	121.0-137.0	172.16 ±1.61	165.0-184.0
Above 8	355.41 ±4.37	126.97 ±0.63	115.0-136.0	131.87 ±1.01	122.0-158.0	174.68 ±1.09	167.0-197.0
3 to above 8 years	323.30 ±3.59	124.25 ±0.38	112.0-136.0	127.82 ±0.53	105.0-158.0	169.45 ±0.67	143.0-197.0

Data was subjected to multiple regression analysis to design a body weight prediction model based on body measurement parameters [Table-2]. Heart girth of Sahiwal female cattle was the first independent variable to be included in the stepwise multiple regression analysis of body weights at different age groups. Among all simple regression model based on height at wither, body length and heart girth, the model based on heart girth was found to be better ($R^2 = 0.626$) as

compare to height at wither and body length ($R^2 = 0.526$ to 0.539 only). HG was preceded with an accuracy of 62.3% in prediction of BW at 3 to above 8 years age group. HT was another independent variable to predict BW at 5-6, 6-7 and 7-8 with accuracy 49.5%, 43.6% and 44.5%, respectively. HG seemed to be the most important independent variable to predict BW of Sahiwal cattle [Table-2].

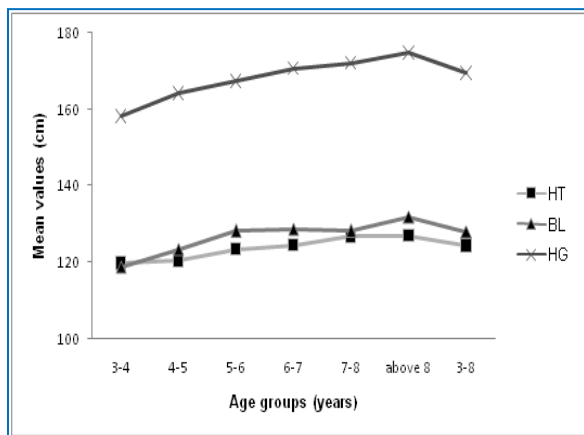


Fig-1 Average morphometric traits of different age groups

Table-2 The best multiple regression equations of body weight (kg) on body measurements (cm) of Sahiwal cattle.

Age groups (Years)	Regression model	R ²
3-4	$-288.91 * + 4.69*(BL)$	0.57
	$-305.82*+2.88*+1.56+1.47*(HG)$	0.63
	$-305.04*+0.02*(HT)+2.89*(BL)+1.47*(HG)$	0.63
4-5	$-323.94*+3.76*(HG)$	0.62
	$-359.20*+1.30*(BL)+2.99*(HG)$	0.64
	$-362.01*+0.09*(HT)+1.26*(BL)+2.98*(HG)$	0.64
5-6	$-424.97*+5.91*(HT)$	0.49
	$-376.38*+2.77*(BL)+1.95*(HG)$	0.59
	$-455.97*+2.10*(HT)+1.92*(BL)+1.52*(HG)$	0.61
6-7	$-243.56*+4.55*(HT)$	0.44
	$-322.59*+2.94*(HT)+2.17*(BL)$	0.52
	$-343.08*+2.39*(HT)+1.94*(BL)+0.70*(HG)$	0.53
7-8	$(-515.872 \pm 233.456)/(6.807 \pm 1.84)(HT)$	0.45
	$-748.33*+4.91*(HT)+2.74*(HG)$	0.57
	$-712.55*+5.50*(HT)+(-2.39)*(BL)+3.88*(HG)$	0.59
Above 8 years	$-295.66*+3.73*(HG)$	0.64
	$-348.19*+1.46*(BL)+2.93*(HG)$	0.69
	$-412.53*+1.36*(HT)+1.34*(BL)+2.40*(HG)$	0.71
Over all	$-347.01*+3.96*(HG)$	0.63
	$-418.57*+2.11*(BL)+2.79*(HG)$	0.68
	$-508.53*+2.10*(HT)+1.57*(BL)+2.19*(HG)$	0.70

*Significant ($P < 0.05$), HT =height at wither, BL=body length, HG= heart girth

Present study showed that the regression analysis of live weight on HG was highly significant ($R^2 = 0.626$, $p < 0.05$). Combination of height at withers and body length in different age groups were found to in the range of 47.5 to 63.1%. Based on multiple regression model live weight changes with linear body measurements of heart girth and body length were predictable with R^2 values ranging out 0.394 to 0.693. The R^2 values showed that 39 to 69 percent of every one kilogram change in live weight was caused by combination of variables of chest girth and body length. Combination of BL and HG is best suitable for prediction of BW at 3 to above 8 years age group with accuracy of 67.9%. Combination of HT, BL and HG were found best suited model with overall highest R^2 value 0.704. Coefficient of determination was also estimated in different age groups from 3 to above 8 years of age and values were ranged from 0.530 to 0.709. The Sahiwal cattle prediction equations were:

1. $-347.013*+3.956*(HG)$.
2. $-418.570*+2.107*(BL)+2.788*(HG)$.
3. $-508.530*+2.100*(HT)+1.567*(BL)+2.187*(HG)$,

Where, Y = live weight, HT =height at wither, BL=body length and HG= heart girth

Discussion

[8]who worked on different breeds of cattle also reported similar results. The result of height at wither was found to be lower than Kurti cattle of Nigeria [10]. [8] also reported similar body length in Kankrej cattle. The body length has been increased up to the age of 5 years, however it become constant beyond this age. This figure was not surprising, since size and shape of animal was expected to increase as the animal was growing with age upto 5 years old. Similarly finding of the heart girth was reported by [6]. Similarly height at wither, body length and heart girth of present study were more or less same with the reports of [9, 13].

Simple linear regression model was used to construct a prediction equation based on a single body measurement. The finding of present study revealed that single equation based on heart girth can be used to estimate body weight in whole population of Sahiwal cattle. [3] also reported that heart girth can be satisfactorily to determine body weights of different cattle breeds. The R^2 estimate in multiple linear regression model based on two variables showed that height at wither and body length combination had poor R^2 value as that of other two combinations. Multiple linear regression analysis based on height at wither and heart girth was found to be moderate. The goodness of fit (R^2) was tested to determine the contribution of these two independent variables. According to this result, the body weight estimation of Sahiwal cattle using chest girth and body length as independent variables in multiple regression produced the moderate accuracies. Present study is more or less similar to that of [1, 4] also found more suitable parameters in Nilotic cattle for body weight prediction with highest value of R^2 .

Combination of HT, BL and HG were found best suited model with overall. Multiple regression analysis based on three body measurements was also supported by [1, 4]. A research finding of [11] was also in accordance with present study who found that HT, BL and HG were more appropriate parameters for prediction of body weight. Studies further indicated that generally body weights of more number were predicted accurately as R^2 of models increased. Further in study in female Sahiwal cattle with increase in age, the accuracy of prediction of body weight increased which may be due to fact that growth is natural process by which animal body increased in external size in all directions at uniform rate. Therefore higher correlation values with regard to different age groups may have been associated with their growth pattern, which facilitated to obtain more consistent measurements and finally higher accuracy of body weight prediction. In present study revealed that more the independent variables inclusion in the model for prediction of live weight, the higher the prediction accuracy of body weight by those variables.

Conclusion

In situation when weighing animals is not feasible or difficult to organize due to unavailability of weighing scale, it is recommended to predict the live weight using regression analysis with single or multiple independent variables that combine wither height, body length and heart girth. Heart girth as sole body measurements while heart girth, body length and wither height in combination could be used for prediction of body weight using simple and multiple linear regression equations in Sahiwal cattle.

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Author Contributions

Study conception, acquisition of data, analysis and interpretation of data: S. S. Sahu, Research design and interpretation of data: S. K. Chourasia, Drafting of manuscript: S. S. Sahu, O. Prakash and S. Jain and Critical revision: S. K. Chourasia.

Abbreviations

BL- body length; BW- body weight; HG- heart girth; HT- height at wither; Kg- kilogram; LW- live weight; r-correlation coefficient; R^2 - determination of coefficient;

SE - standard error.

Conflict of Interest: None declared

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